AUSTRALIAN *TERMITIDÆ*.

Part I.

By Walter W. Froggatt.

INTRODUCTION.

These notes on white ants were first undertaken with the intention of working out the economic aspect of their life-history, more especially their partiality for certain timbers more than others, and the best methods of exterminating them.

There is no family of insects in the warmer and tropical portions of the earth's surface whose members wage such ceaseless warfare against man's handiwork. From their countless numbers, subterranean habits, and insidious manner of attack, none are more difficult to cope with; for often it is not until the damage is complete that their presence is even suspected. In Australia alone thousands of pounds worth of property is annually destroyed by these voracious pests. Having started on this subject, I found both material and notes accumulate so rapidly that I determined (without losing sight of the earlier phase of the question) to expand my notes into a more pretentious work, namely, the study of the habits and life-histories of all the Australian species obtainable, recording my observations when possible from living specimens.

With this end in view, I obtained the sanction of the Curator of the Technological Museum (Mr. J. H. Maiden), who has also greatly assisted me in many ways at this work, to print and issue a circular from the Museum, asking for specimens and giving brief instructions to residents of termite-infested country how to collect them.

It is from the generous way in which my valued correspondents, many of them personally unknown to me (specimens and notes

upon their habits having come to me from all quarters), that I am enabled to enlarge my observations and add much to our general knowledge of their distribution and habits.

I have also had the advantage, in earlier years, of travelling over a considerable portion of the interior of Australia, and afterwards round the whole coast, and therefore start with a personal knowledge of these pests in many phases of camp life, and a fair idea of their distribution over this great island.

Part I.—Distribution.

In going into the literature on "white ants," I have consulted a great number of works of voyages and travels, as well as the scientific papers available; and during these investigations I have been much struck with certain interesting facts relating to the geographical distribution of termites. Therefore, before dealing with the Australian species, I propose to glance at those from other parts of the world.

In the fossil fauna of the Old World termites are very well represented; evidently in bygone epochs, as now, at certain seasons of the year the winged forms swarmed in myriads out of the nests. Fluttering about in their generally aimless manner, many of them alighted upon the soft resin coating the trunks of the pine trees, and became entombed. It is a noticeable fact that nearly all the fossil species have been described from winged forms, no soldiers or workers of most of them being met with. The resin changed to amber has retained the remnants of the prehistoric insect world, and it is to its preservative powers that we owe most of our knowledge of the fossil termites, though others have been described from other formations both from Europe and America.

In 1848 Professor Heer published his "Ueber fossile Ameisen"* describing the fossil insects from the Tertiary beds of Oeningen and Radoboj. This, the first systematical study of the fossil

* Afterwards translated and published in the Quart. Journ. Geol. Soc. London, vi. 1850.

insect world, was followed in 1852 by Dr. Hagen's* work dealing with the fossil termites of the same locality; after describing the different species he states that the climate of Europe must have been much warmer in the Tertiary age than at present to have supported such an extensive insect world, and that out of sixty known species of termites nearly a third of them were fossil. During the years 1855-60 Dr. Hagen† brought out his Monograph, in which he worked out all the then known species, both fossil and recent, among others a fossil species *(Termes grandævus)* from England, the exact locality not being given. This work still retains its place as the text book on matters relating to the classification of the *Termitidæ*.

In 1861 three species were noticed by Hagen in some Sicilian amber obtained by Hope for the Oxford Museum.‡

In 1878 Sterzel described another for which he formed the new genus *Mixotermes*, from the carboniferous of Lugau.§

In 1883 Scudder‖ published an account of his studies of the fossil termites of the Florissant Tertiaries of Colorado; in this interesting paper he gives a general account of all the fossil termites known from other places, and describes six new species, forming the genus *Parotermes*, to contain the first three, while of the others one comes in the genus *Hodotermes* and two in *Eutermes*.

Brongniart¶ has made a magnificent addition to our knowledge of fossil termites in his Monograph upon the study of fossil insects, published last year.

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* Ueber die Lebensweise der Termiten und ihre Verbreitung. Königsb. Naturwiss. Unterhalt., ii. 3, 53-75.

† Monographie der Termiten. Linnæa Entomol. x. (1855), pp. 1 and 270; xii. (1858), 1.; xiv. (1860), 73.

‡ Hagen, H.A. Entom. Weekly Intell. 10, 151, 168, London, 1861.

§ Sterzel, on Fossil Termites. Ber. Ges. Chemn. 1878-80.

‖ Scudder, S. H. The Fossil White Ants of Colorado. Proc. Amer. Acad. Arts and Sciences, 1883, pp. 133-145.

¶ Brongniart, C. Recherche pour servir à l' Histoire des Insectes Fossiles des Temps Primaires, &c. Bull. Soc. d'Indus. Minerale. 1893, vii. (3), p. 127.

At the present time three species of termites are found in Europe, and though they are chiefly distributed along the coast of the Mediterranean and the warmer portions of Southern Europe, one species has been recorded from as far north as Odessa, Russia, where it is said to have done a considerable amount of damage. Of the three species now acclimatised in Southern Europe, only one is said to be indigenous, *Termes lucifugus*, which was known to exist in France at a very early date, though it was not until 1853 that it was reported to have committed any noticeable depredations.* Early in this year they appeared everywhere as a regular plague in the city of Rochelle, and not content with eating up the wood, found their way into the city archives and destroyed many of the State documents.

This species now ranges over the whole of the southern provinces of France, through the Spanish Peninsula, Italy, Sicily, Sardinia, the Morea, Turkey, Cypress, Egypt and Madeira.

A good deal has been written about this species, the latest being Professor Grassi and Dr. Sandias' splendid Monograph on the termites of Catania,† containing an exhaustive account of this species.

The second species, *T. flavicollis*, Fab., was originally a North African termite found at Barbary and Algiers, from whence it has made its way along the European side of the Mediterranean, being found in most of the localities infested by the previous species.

The third, *T. flavipes*, is the common North American species, which has been introduced into Europe, probably in the first instance with logs of timber, and has been discovered as far east as the Bath House of Schoenbruin at Vienna.

Many instances have been recorded of small colonies of termites having been introduced into botanical gardens and hot

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* A. de Quatrefages. Notes on the Termites of Rochelle. Ann. Sci. Nat. (3e sér.) Zool. xx. 1853. pp. 16-21.

† Prof. B. Grassi and Dr. A. Sandias. Atti dell' Accademia Gioenia di Sc. Nat. in Catania. Ser. 4, Vol. vi. 1894.

houses in specimens of foreign timbers; in 1874 such a family was discovered in the palm house at the Royal Gardens at Kew, where they were isolated and kept under observation for some time, specimens being exhibited by Mr. R. McLachlan* at a meeting of the Entomological Society of London in 1874.

Turning to Africa, we find that termites are very generally distributed, about twenty species having been catalogued in Hagen's list from this part of the world; of these two are peculiar to the Isle of France, and one to Madeira; some species are very local and confined to small areas, while others have a very wide geographical distribution. The famous *Termes bellicosus*, immortalised by Smeathman† in the earliest and most complete account of mound-building termites, according to Hagen, ranges round the whole coast line of Africa.

As might be expected, the nearer to the equator the more plentiful the termites; and nearly all equatorial travellers have something to say about these pests. Paul Du Chaillu‡ gives a general account of several species on the west coast in his popular works of travel; Oates§ notices those in Matabele Land, and figures one of their larger nests; while Professor Drummond|| deals extensively with those found in the Lake Nyassa country. Though termites are so plentiful on the main land, I can find no species recorded from Madagascar.

The hold that the white ants have obtained on that rock-bound island, St. Helena, is a remarkable instance of accidental colonization. It is stated on good authority that before the year 1840 white ants were unknown on this island; but at this date a captured slaver was condemned and dismantled at Jamestown, in

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* R. McLachlan. Proc. Ent. Soc. p. xiii. 1874.

† H. Smeathman. On the Termites of Africa and other hot climates. Phil. Trans. Royal Soc. London (Abridged Edition), Vol. xv. p. 61, 1781.

‡ P. du Chaillu. Explorations and Adventures in Equatorial Africa, p. 314, 1868; and My Apingi Kingdom, pp 115-142, 1871.

§ Frank Oates. Matabele Land and the Victoria Falls. London, 1881, p. 134.

|| H. Drummond. Tropical Africa, chap. vi. London, 1889.

the timbers of which there was introduced a South American species (*Eutermes tenuis*, Hagen) common in Brazil. So destructive did they become that several Royal Commissions were appointed to consider the best methods of dealing with them. Melliss* states that they have destroyed over £60,000 worth of property in this island.

Passing into Asia, none are recorded from the northern and central countries. Crichton† says that in some parts of Arabia they are very destructive to young trees, which the Arabs protect by coating the trunks with sheep dung. Two species are catalogued by Hagen from Schiraz, on the Persian Gulf, beyond which until we reach India is a blank. In the latter country, particularly in the southern provinces, white ants are numerous and destructive, though there are apparently not a great number of species among them. *Termes taprobanes*, one of the commonest, is very plentiful in Ceylon, also extending into Borneo, Sumatra and Java, all of those islands having several other species recorded from them.

In the Philippine Islands they are well known. Seoane‡ gives an interesting account of a Spanish man-of-war which was completely destroyed by *Termes dives* while lying in the Port of Ferrol.

Döderlein§ has described a species from Japan. Mr. Knower, of the Johns Hopkins University, U.S.A., a well-known worker on the Termites, tells me that the common American species, *Termes flavipes*, is recorded from Japan, but I presume it has been introduced into the latter country.

Peel‖ has given an account of those from Assam, and Romanis¶ observed them and noted the habits of a species (probably *Termes*

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* Melliss, J. C. St. Helena. pp. 171-176, 1875.

† A. Crichton. History of Arabia, Ancient and Modern. Edinb., 1883, p. 461.

‡ V. L. Seoane. C.R. Ent. Belg. xx. pp. xiv.-xv. 1879.

§ L. Döderlein. Mitth. Ges Ostasiens, iii. pp. 211-212. 1881.

‖ S. E. Peel. Nature, xxvi., p. 343, 1882.

¶ R. Romanis. Entomologist, xvi. pp. 214-215.

taprobanes) in Rangoon. In the Zoology of the Novara Expedition, Brauer has described two species from the Nicobar Islands; while Forbes* noticed them on the Cocos Keeling Islands, where he says they were introduced some years before; this is the only instance in which I have been able to find them recorded from a coral island.

Extending down into the Australian region, there is no record of any species from the mainland of New Guinea, though I have made special enquiries. D'Albertis† mentions them twice on Yule Island, no great distance from the mainland, and it is most likely that they occur inland; for at the present time most of the known portions of New Guinea are either river delta country or mountain ranges, neither of which is suitable for their habitations.

Three species are known from New Zealand, four from Tasmania, and six from Australia.

I have been unable to come across any reference to Termites being found in any of the Pacific Islands, but within this last month I have received some from the New Hebrides. They belong to a very large species and were sent from Aneityum in a bottle full of insects by the Rev. J. H. Lawrie to the Technological Museum. In the Hawaiian Islands Blackburn‡ found two species very plentiful, both of which are American forms and may possibly have been introduced.

The home of the white ant, however, appears to be South America, and its headquarters Brazil; from which country alone twenty-seven species are known. Many of these were collected by Bates§ on the Amazons, who recorded the habits of several species; while Fritz Müller‖ has contributed largely to our

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* H. G. Forbes. A Naturalist's Wanderings in the Eastern Archipelago. London, 1885.

† D'Albertis. New Guinea, Vol. i. pp. 355-401. 1881.

‡ R. McLachlan. On the Termites collected by the Rev. Thos. Blackburn. Ann. Nat. Hist. (5), xii. p. 221, 1883.

§ H. W. Bates. Naturalist on the River Amazon, Lond. 1863; and Proc. Linn. Soc. Vol. ii. 1854.

‖ Fritz Müller. Beiträge zur Kenntniss der Termiten. Jen. Z. Nat. vii. pp. 337, 451, 1873; and l.c. 1875 and 1887.

knowledge of these insects in working out the life-histories of those found in the vicinity of Santa Catherina. White ants have been described from Banda Oriental and the Argentine Republic on the east to Chili on the west.

All the West Indian Islands are more or less infested with them. Cuba has several species. Hubbard* has described the habits of those found in Jamaica, of which the tree nest building *Eutermes rippertii* is the most plentiful; Maynard† has noted them on the Bahamas, and Moseley‡ on the Virgin Islands, while Hagen has catalogued them from St. Domingo and St. Thomas, and Marshall§ has studied the habits of *Eutermes destructor* in Antigua.

Central America is very thickly infested with them, and during the construction of the Panama railway line they did an immense amount of damage to the rolling stock and wood work of the houses. Two officers of the company, Messrs. Dudley and Beaumont,‖ kept a number in captivity and discovered some interesting habits of the commonest species.

The common species in North America is *Termes flavipes*, which is distributed nearly all over the United States, with several others more local in their habits. Scudder¶ has recounted their ravages in Florida. Buckley** has described two species from

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* H. G. Hubbard. Notes on the Tree Nests of Termites in Jamaica. Proc. Bost. Soc. xix. pp. 267-275, 1878.

† Maynard. Notes on the White Ants in the Bahamas. Psyche, v. pp. 111-113, 1888.

‡ H. N. Moseley. Notes by a Naturalist on H.M.S. Challenger, p. 12, New Edit. 1894.

§ T. A. Marshall. On the Habits of some species of Termites in Antigua. Proc. Ent. Soc. p. xxxiv. 1878.

‖ P. H. Dudley and J. Beaumont. Observations on the Termites or White Ants of the Isthmus of Panama. Trans. New York Acad. of Science, Vol. viii. 1889.

¶ S H. Scudder. Ravages of White Ants in Florida. Canadian Entomologist, xix. p. 217, 1887.

** S. B. Buckley. Descriptions of two new species of Termites from Texas. Philad. Entom. Soc. Proc. 1861-63, pp. 212-215.

Texas; they are known in Mexico; and Osten-Sacken* has studied the habits of those in California. In the Southern States along the Mississippi they do a great deal of damage at times, while in 1879 Hagen† reported that they appeared in great numbers at Cambridge, Mass., but disappeared the following season. The most northern limit of the white ant is Manitoba, whence one species *(Termopis occidentalis)* has been recorded by Treherne.‡

To give an accurate account of their geographical distribution in Australia is no easy matter, as much of the country has been very cursorily examined as regards its insect fauna; and few of the naturalists on overland expeditions have collected white ants unless they were very much in evidence. However, all along the eastern coast line, which is mainly forest country, termites are plentiful; in southern Gippsland they are a well-known pest, and more northward in the Goulburn Valley (Victoria) we have several accounts of their attacks upon vines and fruit trees. In the northern parts of Victoria several species are found, but never in great numbers, and seldom forming distinctive nests. Coming into New South Wales, in the Shoalhaven district there are two common species constructing nests, many of the larger nests being from six to seven feet in height. These tall nests are dotted all over the flats, but are seldom met with on the higher hills; they are formed by our common yellow-headed termite, which though common in the neighbourhood of Sydney does not make any kind of nest, but lives under logs and stones or in old timber. North of Sydney, towards Newcastle, white ants are common among the dead timber, the arboreal *Eutermes* building their nests up the trees being the prevailing species. A resident of Cape Hawke informs me that they are very bad in that neighbourhood. I have several species from Uralla where there are plenty of the yellow-

* G. R. Osten-Sacken. Observations on Termes found in California. Proc. Boston. Soc. xix. p. 72, 1877.

† A. H. Hagen. Notes on a Great Cloud of Termites appearing in 1878. Proc. Bost. Soc. N. H. xx. p. 118, 1879.

‡ H. S. Treherne. Notes on species observed in Manitoba. Proc. Bost. Soc. N. H. xix. p. 74, 1877.

headed termites' tall nests; they are generally scattered over the northern districts of New South Wales and southern Queensland. North of Rockhampton they begin to be noticeable as a pest, though the large nests are not very common; from Mackay I have at least five species; towards Townsville they increase in numbers, and about Charters Towers and northward are a very serious trouble. It is only here and there, however, that the large mound nests appear; but the arboreal nesting *Eutermes*, though not always building on the trees, seem to be found all over the country. From Cooktown and all over Cape York the nests are large and numerous; the magnetic nest so well-known in Port Darwin being found on the Bloomfield River, north of Cooktown.*

At Somerset (Cape York), there is one of the most remarkable termite cities in the world; viewed from the sea, and looking up beyond the old Government Residency, now occupied by Mr. Frank Jardine's homestead, it appears as if the plain for a mile or more in extent is covered with pointed pillars six or seven feet in height, broad at the base and tapering to the summit, forming regular symmetrical pyramids. They are thickly dotted over the plain, often only a few yards apart; the effect is much heightened if the grass has been freshly burnt off, as it had been the first time I passed Somerset.

Several writers have noticed this city of the termites. Moseley† likens them to kiln chimneys; he says that it gives the country the appearance of a pottery district in miniature, and states that many of them are ten feet high. D'Albertis,‡ writing of this place, says:—"Termite nests, both on the hills and plains, measured often ten feet in height and thirteen feet in circumference at the base"; he found upon opening them that many were attacked and often almost exterminated by large black ants.

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* D. Le Soeuf. A visit to the Bloomfield River. Victorian Naturalist, Vol xxi. 1894, p. 25.

† H. N. Moseley, l.c. p. 302.

‡ D'Albertis, l.c.p. 229, Vol. i.

On Thursday Island and the many islands round Cape York, the same form of nest is met with; turning down into the Gulf country and to the watershed of the Flinders River and its tributaries, we find one of the most termite-infested localities in the world. Nothing is too hard or dry for them; stockyards, fences and houses only last for a few years in spite of all precautions; a branch is attacked as soon as it is dead, and in many places no stumps or dry wood is left in the scrubby forests; everything is swept up as it were by these underground gnomes, who as forest scavengers do their duty thoroughly. If one cuts some grass for a bed and leaves it lying upon the ground for 24 hours, anywhere on the lower Flinders, one will find it cut up into fine chaff by the termites which have come up from the earth beneath, and if one is inexperienced enough to leave his blankets on the top of it, he will find all the lower folds riddled with holes. Earth scoops and carts that had been left in the paddocks for a while at Cambridge Downs Station were brought in with the felloes of the wheels (hard seasoned timber) gnawed to a shell, while things in the store had to be constantly turned over, as they even carried their clay up into the cases of soap, jams and meats, which not only destroyed the boxes but caused holes to rust in the tins and spoil their contents. At a hut on this station where I used to camp, the sides were built of upright saplings about six inches in diameter; the termites had worked their way up these, reducing each to a simple pipe of bark. In the silence of the night I have often lain awake listening to the sound of the millions of tiny jaws gnawing at these timbers, voices of the night as strange and uncanny as one could well imagine.

Passing from Normanton towards Port Darwin, we are still in thickly infested country, and about ten miles out from Palmerston are some of the tallest termite nests in the world. I am indebted to Mr. N. Holze, the Curator of the Botanic Gardens there, for photographs and specimens from these and the magnetic nests, which will be dealt with in detail later on, together with the species that form them.

In that portion of North-western Australia stretching across from Cambridge Gulf to Roebuck Bay, known as the Kimberley

district (where I spent over twelve months), and probably as far as the De Grey River, all through the open forest flats and along the edge of the sandy "Pindan" country are found numbers of large broad nests, from five to six feet in height, rather constricted at the base, but swelling out on the sides in rounded masses, where additions have been made, while the summit is broad and rounded, giving them somewhat of a mushroom-like appearance.

As there are few or no trees over a belt of country to the westward of the De Grey River for over three hundred miles, the termites apparently disappear, nor can I find that they construct nests or are at all noticeable in any other part of Western Australia, but they have recently been reported as having attacked the telegraph poles between York and Coolgardie. This also applies to South Australia, though it must be remembered that scattered bands of termites may be found in almost any part of Australia which may attack an odd plank or tree, but they are not in evidence as a serious pest.

In the vast tracts of dry and sparsely timbered country in central Australia, termites are naturally scarce, and probably wanting altogether in many parts of it. I never remember seeing a mound nest west of the Darling or even in the northern districts of Riverina, but with further observations from my many correspondents, I hope to enlarge our knowledge of their distribution and supplement this necessarily rough sketch.

Termitaria and their Structure.

Broadly speaking, termites' nests may be separated into three different typical forms, each of which undergoes several important modifications in outward appearance, but always has the same internal structure. The first may be called the turret or regular mound nests, varying from eighteen feet in height to a little pinnacle only a few inches above the surface, and sometimes simply a bald patch upon the ground. In these abnormally high ones the clay is generally carried up the face of a dead tree, which is gradually sheathed with this coating, while the trunk beneath is changed nto triturated wood which in time becomes converted

into a hard papier-maché-like substance. The foundations of the smaller mound nests are commenced at the base of a stump or thrown up from under a fallen log. A correspondent in Kimberley, W.A. (W. O. Manbridge), tells me that a species there forms its nest over the spinifex bushes. I have examined a great number, all of which give proof of this, and they can be found in all stages of growth. Though later writers have doubted the fact, Hooker* as early as 1855 wrote that the Indian species always commenced their nests over decaying woody or vegetable matter.

That the different species have peculiar ways of their own when forming their mounds must be allowed, but the internal architecture of all of them is based upon one uniform plan, and as an illustration of this I will describe the commonest large earth covered nest found in New South Wales.

During a visit to the Shoalhaven district towards the end of last year I had ample opportunities of examining a number of these large nests, which are scattered thickly over all the open forest country along the river, but are seldom found towards the top of the ranges, the nests of the smaller Eutermes taking their place. Roughly speaking, the average is about one nest varying from three to seven feet in height to every four acres. They vary a little in outward shape, but a well-designed nest about six feet in diameter at the base will run up nearly the same height, with a slight slope on the sides to the apex, which is dome-shaped, not more than three feet in diameter. The enveloping walls consist of the surface soil only (a pale yellow sandy-brown) very hard on the weatherworn surface, but much softer when cut into. The basal portion of the walls are very much thinner than the dome-shaped summit, the lower portion of the wall often not being more than a foot in thickness, while the summit has a two-foot wall over it. All this earth is gathered from the surface by the termites and not mined from below, as many popular writers have asserted. In this locality this is plainly demonstrated, for three inches below the surface

* J. D. Hooker. Himalyan Journals, London, 1855, Vol. i. p. 18.

there is nothing but coarse gravel of which the large nests of the common reddish-brown ant (*Iridomyrmex purpureus*), also common in this district, and which construct large underground chambers, are wholly composed.

The foundation of the termite nest rests upon the surface and is complete in itself, and if you cut one round the base and then insert a lever under the edge it is very easy to overturn the whole nest; underneath the ground is smooth and hard with only a few insignificant passages leading below.

Under normal conditions the enveloping earthy walls contain very few insects, though there are always a few winding passages running upwards and traversing them at irregular intervals; upon the removal of this outer wall you expose a pyriform mass of roughly granulated woody substance in contact with the covering wall at the base, but gradually receding from it toward the apex, where a space of several inches divides them. The summit of the mass on the outside can be easily broken off in lumps, but as you cut into it it becomes harder and more solid; galleries run all round these masses and form irregular mazes of roadways lower down, giving the termites access to all parts of the structure. This portion of the nest (all the inner portion enclosed in the earthy dome) is organic and is chiefly composed of triturated wood which has at one time been gnawed up by the termites and then evacuated by them; each of these granulated lumps shows a distinctly foliated structure as if it had been formed in thin coats; no doubt when the fresh wood supplies are used up, this part of the nest is again eaten.

Immediately in the centre of the nest, about six inches above the base, is a rounded mass about as big as a man's head, formed of very thin layers of woody matter like brown paper, full of fine chambers and passages, the layers very close together and folding round each other towards the centre. This is the "nursery" of the termitarium, and generally contains thousands or rather millions of delicate white larvæ, many of them no larger than a pin's head. I have never seen any signs of fungi growing in these nurseries as mentioned by many writers, but the walls have a curious mottled

appearance and are full of very fine perforations; and the centre of this structure, which is very brittle and crisp, has a distinctly higher temperature than the outside.

On either side of this nursery where the ordinary galleries lead out of the finer central cells, the eggs are found piled up in little heaps like little grains of sand, white and rather elongated; perhaps as much as a big tablespoonful being found on one patch, and there may be several heaps close together. The formation now becomes slightly terraced just beyond the eggs still on a level with the nursery, and after breaking through a number of very stout terraced chambers we came upon that containing the queen; the floor of the chamber is perfectly flat and smooth, with the roof forming a low dome over her, about six inches in circumference, not unlike the cavity under an inverted saucer or watch glass. Though in many popular descriptions of termitaria it is invariably stated that there is a male with the gravid queen, I have never found one in a fully developed nest, though frequently finding a pair under stones or logs where they are evidently just commencing to found a community. Sometimes they were so much alike that it would be impossible to say which was king or queen, but in others found in similar situations the body of the queen was beginning to show the enlargement of the pregnant or gravid state and the difference of the sexes was discernible. As Fritz Müller* has shown, in the first stages of the winged adults when the insects are leaving the nest the sexual organs of the males and the ovaries of the females are very rudimentary, and it is not until the act of copulation that they become perfected.

On the evening of the 5th of October, while opening out nests on the Shoalhaven flats, I came upon a large nest scarred with narrow cuts, which upon examination proved to be slit-like openings about a line or more in height and an inch or less in length. These were all over the outside of the termitarium, and in each slit, with their heads level with the surface of the termitarium, but not showing beyond, was a regular row of soldier

* Fritz Müller. Beiträge zur Kenntniss der Termiten. Jen. Z. Nat. vii. pp. 337-451, 1873.

termites guarding the openings and not letting anything come out. Upon cutting down the walls these openings were found to run into low but broad roadways extending right through into the heart of the nest thronged with winged termites waiting until the withdrawal of the guards at the gateways. As soon as a breach was made in the walls they commenced to swarm out from all parts of the nest, and we were soon enveloped in a cloud of black winged termites buzzing about and dropping all round, causing quite a distinct noise, audible at a distance of several feet, an immense number falling to the ground. These winged specimens were found in chambers and passages all over the nest. Previously in the vicinity of Sydney I had noticed larvæ with rudimentary wings in the early part of the year, but in their earlier stages the wings grow very slowly until after the winter months are over. Termites were noticed flying about near Sydney on the 2nd and 3rd of November in great numbers.

As to the age of these large termitaria, it could only be positively ascertained by the extended observations of a resident in termite infested country. But out of a great number I have opened out I have only found one deserted, and it was only on cutting a portion of it down that I discovered this fact, for to all outward appearance it did not differ from the inhabited nests.

Smeathman and Savage, writing on the celebrated *Termes bellicosus*, state that the fullgrown queen lives for five years, the former being responsible for the statement that she lays 60 eggs a minute and never stops (presumably during the five years). Though he produces no evidence for this statement, it has been copied into nearly all the popular works and text books on entomology up to the present date, even appearing in Kirby's Text Book, published in 1885. As the working community of the termitarium have a fresh supply of females to come forth every season, and also very often a number of supplementary queens in the nest (I have obtained 10 specimens of these queens from one nest, which are I believe perfectly distinct from the ordinary winged queens, as they are not recruited from the winged forms but produced directly from the egg); it is therefore pretty

evident that the fate of the community does not hang upon the prolongation of the gravid queen, as it is not at all a difficult matter to replace her with a young and vigorous successor when necessary.

From my own observations I do not think that the queen of any Australian species either lays eggs so rapidly or lives so long. I have on several occasions unearthed a queen in a very sickly looking condition, with her abdomen yellow and wrinkled, and with her antennæ and most of the tarsi broken off, though the nest from which she was taken was swarming with life and apparently in the height of prosperity.

I should not be surprised to find that many of the larger mound nests last for a great number of years, and that white ants may also exist in their nests long after they have destroyed all the woody matter they contain, for in the tropical parts of Australia before the wet season sets in (about the middle of December) they stored food supplies. When examining some of the large rounded termite mounds near King's Sound (N.W. Australia) I found on cutting into them that all the outer galleries were full of bits of grass cut up like fine chaff, which ran out in little streams to the ground as soon as the passages were opened.

Professor Drummond* in his account of African termites previously quoted, notices the immense amount of clay carried up the trunks of trees by these insects, which, he suggests, when it is swept down by the tropical rains and is scattered over the surrounding land is a great agent towards fertilizing the soil, and that termites probably take the place of the earthworms of more temperate regions. This statement requires confirmation, for in the first instance the soil used by the termites is gathered from the surface of the ground, and whenever a large mound has been destroyed in this country I have always noticed that nothing grew upon or near it for a long time, but it had a dry, barren appearance as if the clay had been burnt.

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* Drummond. Tropical Africa, l.c.

The remarkable fineness of the earth collected by the termites for their nests is put to a practical use by the natives of Ceylon,* who use the clay to make moulds in which to cast the finer specimens of silversmith's work; and it is also made into plastic material for fashioning some of their earthenware gods, while in India it is also used for polishing purposes.

In Australia the large mounds are often demolished for the sake of the clay they contain; it is mixed up with water and made into sun-dried bricks for building houses, while beaten up into mortar it makes excellent floors; both here and in South Africa the smaller ones are turned into baker's ovens after the interior has been burnt out.

Another remarkable thing about the termites is that no matter how dry the season, or parched up the country, if a nest is broken no time elapses before it is mended with damp clay, while the nest always contains a certain amount of moisture, without which the termites could not exist. The question then arises, how do they manage to retain this humidity in a rainless and dewless country? Dr. Livingstone† remarking on this in South Africa, says:—"Can it be that they have the power of combining the oxygen and hydrogen of their vegetable food by vital force so as to obtain water?"

The internal structure of the "Magnetic Nests" of Port Darwin, the large round topped ones of the North-West, and the pyramidal shaped ones of Cape York, though differing very much in their external architecture, all, with slight modifications, agree with the Shoalhaven termitaria in their internal structure.

The next group of termite nests are formed by the members of the genus *Eutermes*, which form a very distinct group, in which the soldiers, instead of having double scissor-like jaws, are provided with heads prolonged into pike-like foreheads which gives them the name of "nasuti" soldiers. It was at one time a

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* Sir J. Emerson Tennant. Sketches of the Nat. History of Ceylon, chap. xi. 1861.

† Dr. Livingstone. Missionary Travels and Researches in South Africa, London, 1857.

common idea that some nests contained both pike-headed and scissor-jawed soldiers, but it is now known that this is not the case, the *Eutermes* communities being quite distinct from those with double-jawed soldiers.

The Eutermes build two kinds of nests, or rather similar nests in different situations, either terrestrial or arboreal. Those built on the ground are most common about Sydney, and are formed over a small stump, never more than two to three feet and a half in height, perfectly round at the base, with the summit rounded and dome-shaped. They are generally dark brown or black, even the outer surface being an admixture of earthy and woody matter, and often with hardly any earth in their composition. There are no enveloping walls. The true nest starts from the surface, the whole being full of cells and chambers, though they are fewer and the nest much harder and tougher on the surface; working towards the centre the soft papery structure (similar to that of the large nests) is found—"the nursery." The queen and eggs are not very far away from the nucleus, but the terraced portion is not of the same regular formation as that of the large nests, and there is virtually no distinct "royal chamber," but the queen is found about the centre of the low, flat chambers. In one nest I found three well-developed queens, all laying eggs; and within three or four inches of each other but separated by overlying terraces. The bulk of all these nests is almost all woody matter which has been passed through the bodies of the termites and been voided by the workers; yet if a terrestrial nest be cut down on one side they will rebuild it with grains of sand or earth cemented together with excreta. Ridley,* speaking of the Malay Peninsula, says that the termites do not live in the sandy soil. This is not the case in Australia, for I have found *Eutermes* nests in almost pure sand at Botany Bay, near Sydney, which though when first opened were constructed of woody matter, yet two months afterwards one was rebuilt with sand cemented together into a solid mass.

* H. N. Ridley. The Flora of Eastern Malaya. Trans. Linn. Soc. Vol. (2nd Ser.) iii. p. 270, 1893.

Another nest was found upon the summit of a rock at Manly, near Sydney, apparently built over the stump of a small tree that had been growing in a cleft of the rock. A number of covered galleries led down over the face of the rock into the ground, and in several places where they passed over a sharp angle the covered ways were transformed into tubular bridges from point to point; these galleries averaged from $\frac{1}{2}$ to a $\frac{1}{4}$ of an inch in breadth and were constructed entirely of vegetable matter. When one of the galleries was broken the soldiers rushed out in a small body, scattering on either side of the damaged roadway; after hunting about on the surface of the rocks, they then retreated to the breach, which they all entered and formed a rank along either side, standing just far enough apart to touch the tips of each other's antennæ. While they stood in this regular line with their heads up and their antennæ moving backwards and forwards, the workers appeared, each carrying in its mouth a bit of wood or fragment from the wall, and, passing between the soldiers who were standing guard, deposited its burden upon the edge of the wall and turning round evacuated a small drop of dark brown liquid from its anus upon the top of its brick and then disappeared, the next one taking his place and going through exactly the same performance, an endless gang of workers following each other and rapidly reducing the size of the hole; a gap about an inch long and half an inch deep was rebuilt in half an hour. Unlike the two-jawed termites, which never rebuild their nests in the daytime, the Eutermes do not seem to dislike the light, but will expose themselves in the hottest sunlight when mending their nests.

The nest upon the rock at Manly was partly demolished and a small queen obtained from the centre in February, and about three months afterwards was found rebuilt, the material being all woody matter, crisp and thin, and cutting up like egg shell. I have seen one of these nests built on the top of a gate post, another upon the top of a pile in a bridge, the termites having formed it under the iron cap in the cavity between it and the top of the pile; it lifted off in a single mass like a small cheese.

Many of the *Eutermes* nests are built in trees, sometimes upon a dead tree, the dead branch of a live one, the rough-barked Eucalypt being generally chosen, as the galleries coming up from the ground are skilfully hidden in the inequalities of the bark, though when they do come to a bare surface they go straight ahead, forming a regular uniform covered way. Not only is there a constant stream of workers and soldiers passing up and down the galleries, but the enormous amount of life one of these arboreal nests contains is something astounding; there seem to be more termites than nest material when they are first broken open.

The dark, almost black, colour of the nests makes them very conspicuous objects on a bare leafless tree. Arboreal-nesting species of this genus have been described from many parts of the world; in Brazil the nests are known as "negro heads." Moseley* gives a description of them at St. Thomas (Virgin Islands) and states that they are often as big as a small hogshead. Hubbard† has worked up the arboreal species of Jamaica; and Miss Ormerod‡ has noted from British Guinea large spherical nests encircling the branches of trees.

In the third group of termites I include those that do not build mound nests, but live in communities under logs, stones, and all sorts of dead wood and timber. A number of our species never appear to build any well-defined nest, but like wandering gypsies, pitch their settlement in any suitable place, like the common American species, *Termes flavipes*, the real nest and queen of which are yet unknown. While some of them form regular little families distinct in themselves, others are predatory bands which find a suitable place to form an encampment and devour everything they can find; they are frequently connected with a large nest at some distance, to which they all retreat when disturbed.

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* H. N. Moseley. Notes by a Naturalist on H.M.S. Challenger, p. 12, n. ed. 1892.

† H. G. Hubbard. Proc. Bost. Soc. xix. p. 267, 1878.

‡ Miss E. A. Ormerod. Proc. Ent. Soc. 1881.

However, different localities seem to give them different habits, for the mound builder of the Shoalhaven district is the same species as that which does most of the damage to the woodwork of the houses about Sydney, yet I have never been able to find a mound formed by them within thirty miles of Sydney, though it is the commonest species of this neighbourhood, being found under stones, logs, bark, and in tree trunks.

About the middle of last year it was discovered that the white ants were in the floor of the Record Room in the offices of the Department of Education in Bridge-street, where I had an opportunity of seeing the method of attack.

I found that the floor, which was old and attacked with dry rot in places, had been riddled all along the hard gum (probably ironbark) joists for a distance of 15 to 20 feet all round what had evidently been the centre of the nest, as a great mass of clay had been raised up from the ground between two joists round which the timbers were perfectly honeycombed. The nest and timbers round it were full of soldiers, workers and young winged forms, but I saw no sign of a queen, though as the floor had been uncovered the night before this was hardly to be wondered at. This nest, I should think, had been under the floor for some years; and it was only from their beginning to eat through the hardwood flooring boards that the termites were noticed.

On several other occasions I have obtained specimens taken out of buildings, and it has always proved to be the same species. Sometimes they attack only a single board or joist and then leave the place, but at other times they eat on till disturbed. Mr. Chisholm, of Torrens Creek, North Queensland, tells me that they are easily frightened by thumping against the board or wall they are destroying, and run back, huddling together like a flock of frightened sheep. No timber is really termite-proof unless protected, for though they have a marked preference for some woods, yet if they cannot get what they like they take the nearest; thus in Normanton *Melaleuca* is said to be ant-resisting, yet further down the Flinders they show a marked preference for it. The Jarrah (*Eucalyptus marginata*) of Western Australia is another

reputed termite-proof, but I have a portion of a plank, received from Mr. C. French, of Melbourne, which has been half consumed by them. The Leichhardt tree of Queensland is also quoted, but at Dalrymple, N.Q., I have seen large logs taken out of an old house riddled with their holes. About Sydney when attacking houses they will seldom touch red wood if there is any clear pine. I have seen a piece of red wood that was nailed to a clear pine board, the latter being only a shell while the former was only slightly grooved by them on the outer surface.

I have noticed that about the neighbourhood of Croydon while nearly every old hardwood fence shows their ravages more or less, they seldom seem to attack soft wood picket fences. But the hardness of wood is no impediment to them. They show a marked preference for the stumps and logs of dead Eucalypts over those of wattle, Casuarina, and the smaller forest trees. Near Hornsby I found them at work on the trunk of a large dead white gum that was as hard and solid as bell metal; they had come up from the ground beneath the roots and just below the surface, boring straight into the wood and then turning upwards, cutting a clean cylindrical tunnel a quarter of an inch in diameter. It is therefore not surprising that they sometimes gnaw holes in sheet lead, which is much softer than many woods attacked by them.

White ants are in many instances introduced into buildings in the city and suburbs by means of fire-wood; during this last season I have exhumed three large family parties, containing enough soldiers, workers and immature winged specimens to found a very respectable colony; these insects would remain in the log probably until the early part of the summer and then migrate to more roomy quarters. They will live for several months in a tightly closed up tin or tube without any further attention, and though they cannot live more than two hours in sea water and a little longer in fresh, yet in the heart of a dead log they might float or drift a considerable distance without being destroyed.

In conclusion, I must tender my thanks to the following correspondents :—Messrs. G. McD. Adamson, of Uralla; Norman Ethridge, Colo Vale; F. B. Miller, Moree; S. Russell, Bowral; H. Rumsey, Barber's Creek; J. Mitchell, Narellan; and my father

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From the Northern Territory I am in receipt of photographs of the nests and the species forming them taken by Mr. N. Holtze, the Curator of the Botanical Gardens at Port Darwin; while Museum specimens have been forwarded by Mr. J. G. O. Tepper, of Adelaide.

I have had a great number of promises of assistance from various residents in Western Australia, but as yet have only received one lot, but a very interesting collection; from Mr. W. O. Mansbridge, the Warden at Hall's Creek, Kimberley, N.W. Australia.

Though two species are described from Tasmania, I have been unable to enlist anybody to collect specimens.

From New Zealand I am indebted to Captain Hutton and Mr. T. F. Cheeseman for placing me in communication with Captain Broun (the Government Entomologist), who has sent me specimens of two species described by Brauer.

From America I have been generously assisted with named specimens from Mr. L. O. Howard (the State Entomologist) and Mr. H. McE. Knower, of the Johns Hopkins University, while Mr. S. S. Scudder, Dr. Packard and Mrs. Dudley have forwarded me papers on these insects.

Mr. D. Alcock, of the Indian Museum, Calcutta, sent me specimens of *Termes taprobanes*. The Director of the K. K. Naturhistorisches Hofmuseum in Wien sent me co-types of F. Brauer's named species from Australia, collected by the Novara Expedition in 1868.

I have Professor B. Grassi and Dr. A. Sandias' splendid Monograph upon the Termites of Catania sent me by the authors, while Mr. W. F. Kirby, of the British Museum, has examined a series of specimens sent to him, and promised me any assistance in working them out.